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AIC-18

INFORMATION SHEET ON DEHYDRATED CABBAGE AND CELERY*

Western Regional Research Laboratory, Albany, California
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
U. S. Department of Agriculture

Production, Varieties, Storage, Preparation

Cabbage.--Cabbage is a widely grown crop, but of the 1.4 million tons produced in 1942, two-thirds was grown in New York, Texas, Florida, Wisconsin, California, and Pennsylvania. The northern States, which produce the late crop, supply nearly all the cabbage used in sauerkraut, and since these States contain the areas of heavy production they will probably furnish most of the cabbage for dehydration.

The late-cabbage States produced an average yield of 10 tons per acre in 1942, against an average of 7.6 tons for all cabbage-growing States. The harvest in the late States generally starts about June and continues until November. The winter and spring crops in the southern States are harvested from November to May.

Little dependable information is available on the relative suitability for dehydration of varieties of cabbage. For a full-green product, the Savoy and other green-leaved, loose-headed types of cabbage are considered best. When dried, they have a better appearance and flavor and a higher vitamin content than the solid-head, white types. But the Savoy types are not grown extensively in this country. They are expensive to produce because of low yields, and seed supplies are too limited at present.

The small, early, low-yielding varieties of cabbage will probably be used very little, and attention will center on the midseason or the late varieties. Midseason varieties are Copenhagen Market and its wilt-resistant counterpart, Marion Market; Glory of Enkhuizen and its wilt-resistant strain, Globe; All-Seasons and its strain, Wisconsin All-Seasons. All of these are grown for the midseason market and especially for kraut making. At present it is not definitely known how these varieties compare for drying purposes. Late Flat Dutch, Danish Ballhead, and Wisconsin Hollander are the more important varieties grown for the late market and for storage, but not for kraut making.

Danish, Domestic, and Pointed Head are satisfactory for drying. These may turn yellow upon dehydration, however, unless special care is taken during blanching and drying. In general, they require less blanching and lower drying temperatures than the Savoy varieties.

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* Supersedes Information Sheet ACE-165

Cabbage is usually stored at a temperature ranging from 32° to 35°F. by ventilation with cold outside air. The storage house must be insulated to prevent freezing, and it must be well ventilated to carry away the large amount of heat and moisture given off by the cabbage. Many such storage houses can be found in New York, Pennsylvania, Michigan, and Wisconsin. The cabbage is stored in bins 4 to 5 feet wide, 10 to 20 feet long, and about 5 feet deep. The bins are usually made with slatted floors and solid partitions, and they are often several tiers high, one bin above the other. The best method of storage is on slat shelves with the heads 1 or 2 layers high, but the expense of this method may be prohibitive. Cold storage is too costly for this crop. The ideal storage conditions are 32° with 90 to to 95 percent humidity. Late-crop cabbage will keep 3 to 4 months if properly stored. The longest-keeping varieties belong to the Danish Ballhead class. Early cabbage does not keep more than 3 to 6 weeks at 32°.

Cabbage is usually handled in bulk or crates, the former method being most common. As most of the vitamin C is contained in the outer leaves, care should be taken to conserve them. Considerable hand labor is required, but can be offset by a properly arranged conveyor system from the unloading platform or storage house to the trimming table.

Trimming consists of removing the outer bruised and discolored leaves. The trimming waste will range from 15 to 37 percent. After trimming, the core is removed with rotary cutters especially designed for this purpose.

The cabbage is next washed by strong sprays in a rotary drum washer, in order to clean out the dirt and grit. By means of a rotary cutter, the cabbage is then coarsely shredded into pieces not less than 1/8 inch nor more than 1/4 inch wide. Too fine shredding causes the shreds to collapse during blanching and if dried in this condition, the material will stick to the loading surface and will require a longer drying time.

Celery.--Celery is a cool-season crop, but is not as hardy as spinach or beets. It is adapted to winter culture in the lower South, and in the central regions it may be grown either as an early spring or as a late fall crop. Farther north, in certain favorable locations, it can be grown throughout the summer. Celery requires a peat or muck soil, except in the irrigated areas of the West. It is comparatively high in labor requirement.

In California and central Florida celery is produced in important quantities in the fall, winter, and spring. Midseason and late summer crops are grown mainly on the muck soils of Michigan, New York, New Jersey, and Pennsylvania, with smaller acreages on the irrigated lands of the Pacific northwest.

California, Florida, Michigan, and New York grew approximately 85 percent of the 1942 celery crop in the United States. The late spring celery crop in California yielded 25 tons to the acre as compared with an average of 15 tons for other celery crops during the year. The New York yield was 20 tons per acre; that of Florida and Michigan, 13 tons, and the average yield for all states, 14 tons per acre.

Golden Self-Blanching and Golden Plume are well adapted to early production. For storage, Easy Bleaching Green, Utah, and Giant Pascal are best. Other excellent varieties are Crispheart, Emperor, and Winter Queen.

Much of the late celery grown in the northern states, notably in Michigan and New York, is placed in storage where it can be preserved for a period of from 2 to 4 months. This supplies the market during the late winter until the new celery from California and Florida becomes available.

While in storage, celery must be kept as cool as possible without freezing. Additional requirements are an adequate air circulation and a high relative humidity (90 to 95 percent). In order to prevent overheating, the crates should not be piled more than 4 high.

Celery is dehydrated chiefly for use as a seasoning and in soup or soup mixes. Steps in the preparation are fairly simple. The diseased and discolored parts are first trimmed out by hand; then the stalks are given a thorough washing. For soup mixtures, celery is finely shredded, leaves and all, and spread directly on the drying trays. For other purposes, the leaves, which dry more rapidly, are trimmed from the thick, fleshy stalks by hand and dried separately. The leaves are shredded or dried whole. The stalks are cut by a rotary slicer into transverse slices about 1/2 to 3/4 inch thick.

Blanching

Cabbage.--Just prior to blanching, cabbage shreds should be washed with sprays of clean water. Since cut leaves lose their ascorbic acid (vitamin C) content rapidly, it is necessary that the material be blanched immediately after shredding. If this cannot be done, the cut leaves must be held in a 2-percent salt solution. Under no condition should the cut cabbage be held for more than 1 hour between cutting and blanching.

The product must be blanched in live steam at a temperature of not less than 190°F. until the catalase system is destroyed. This should require not more than 3 minutes in a properly operated blancher. Care should be taken to avoid overblanching, which causes an undesirable color in the finished product. A suggested blancher loading for shredded cabbage is 1 to 1-1/4 pounds per square foot of loading surface. If a delay occurs between blanching and dehydration, it will be necessary to cool the product down to 65° or 70°. by means of cold-water sprays; otherwise the color of the finished product may be injured. The blanched product should not be held longer than 1 hour before being dried.

Celery.--The method of blanching celery is the same as for cabbage, with the exception that celery, under ideal conditions, will require about 2 minutes. As is true of cabbage, present government purchase specifications require inactivation of the catalase system.

Dehydration

The moisture content of raw cabbage and celery varies with the variety, maturity, locality, and storage conditions. Since moisture content

influences the yield of the dry product, it is important for the operator to know the moisture content of the material to be used. The approximate range in moisture contents of raw cabbage and celery are shown in the tabulation below. From these percentages the weight in pounds of water in each vegetable per pound of "bone-dry" matter has been calculated and is shown also. The bone-dry matter must not be confused with the finished product, which contains a low percentage of moisture, as shown by the maximum percentages permitted under government specifications. The ratio of water to bone-dry matter in the raw product is useful to the operator because it shows him how much water is contained in the product and makes readily calculable the weight of water that must be removed.

Vegetable	Moisture in raw vegetable (percent)*		Lbs. water per lb. bone-dry matter		Moisture specifications (maximum percent)
	Range	Av.	Range	Av.	
Cabbage	88.4-94.8	92.4	7.6-18.2	12.1	4.0
Celery	89.9-95.2	93.7	8.9-19.8	14.9	4.0

*From Chatfield and Adams: Proximate composition of fresh vegetables. U.S.D.A. Circular 146 (1931.)

The drying ratio, or its converse, the drying yield, can be calculated from the change in moisture content of the material in the drying step alone. The drying ratio is the ratio of the weight of material entering the dehydrator to the weight of the same material as it leaves the dehydrator commercially dry. The drying yield, usually expressed in percentage, is the reverse ratio of the same two weights. These ratios are useful in the design of dehydrators and for comparing the prospective yields of product from different types of raw material, since it may usually be assumed without serious error that the moisture content of the blanched, prepared material entering the dehydrator is the same as that of the raw vegetable. The following values of drying ratio and drying yield were calculated in that way from the moisture ranges given in the foregoing table, with the moisture content of the commercially dry product assumed to be 4 percent.

	Drying ratio, lbs. entering dehydrator per lb. leaving it at 4 percent moisture		Drying yield (percent)	
	Range	Av.	Range	Av.
Cabbage	8.2-18.4	12.6	5.4-12.0	7.9
Celery	9.5-20.0	15.2	5.0- 9.8	6.5

The operator is more directly interested in the overall shrinkage ratio, that is, the weight of unprepared raw product required to yield one pound of finished product which meets specifications. This may also be expressed as the reversed ratio, usually as a percentage, and is then known as the overall yield. The overall shrinkage ratio is always substantially higher than the drying ratio, and the overall yield lower than the drying yield, because all weight losses incurred at various steps of the process, such as culling, washing, trimming, and inspecting, must be discounted. Averages and ranges are not included here, because these other losses vary widely.

For the dehydration of cabbage or celery shreds, the following tray loadings for different systems of air flow are suggested for trial:

Vegetable	Cross circulation of air	Through circulation of air	Finishing bin
	Lbs. per sq. ft. loading surface		
Cabbage	0.75-1.0	6.0- 8.0	A loading depth of 2 to 3 feet for cabbage and 2 to 4 feet for celery is probably satisfactory
Celery	1.0 -1.5	6.0-12.0	

Variations between varieties and within a single variety due to maturity, cultural conditions, or storage conditions make it necessary to determine safe operating temperatures by trial. The general principle to be followed is that the finishing temperature shall be carried as high as possible without damage to the product. To serve as a guide the following temperature conditions for different systems of dehydration are suggested for trial.

	Cabbage °F.	Celery °F.
Counterflow Tunnel		
Hot-end temperature	145	Not over 145
Wet-bulb depression at cool end	At least 25	At least 25
Parallel Flow Predrier		
Hot-end temperature	180	180
Cool-end temperature	Not over 150	Not over 160
Wet-bulb temperature	Not over 110	Not over 110
Wet-bulb depression at cool end	At least 30	At least 30
Center Exhaust Tunnel		
Primary end	Same as parallel-flow predrier	
Secondary end	Same as counter-flow tunnel	
Conveyor-type Drier--Through Circulation		
Primary end, first section:		
Dry-bulb temperature	180	180
Wet-bulb temperature	Not over 110	Not over 110
Primary end, second section:		
Dry-bulb temperature	150	160
Wet-bulb temperature	95	100
Finishing end:		
Dry-bulb temperature	Not over 145	145
Wet-bulb temperature	85-90	90

Bin Finishing Drier	Cabbage °F.	Celery °F.
Dry-bulb temperature of air entering drier	120-130 (at least 10° less than finishing temperature in dehydrator)	
Relative humidity	10 percent or less	

Cabinet Drier

Starting temperature:		
Dry bulb	165	165
Wet bulb	100	100
Finishing temperature:		
Dry bulb	135	125
Wet bulb	80	80

As drying in a cabinet progresses, the dry-bulb and wet-bulb temperatures are lowered by steps until the desired finishing temperature is reached. The temperature changes are made on the basis of a time schedule previously determined by a pilot run in which the temperatures are lowered in steps as the moisture content of the product is lowered. Since moisture is lost most rapidly at first, the temperature must be lowered after a relatively short time interval. Further adjustments are made after gradually lengthening intervals. Fully a half of the total drying time should be taken at the temperatures given above as finishing conditions.

Each operator will have to depend upon the method of trial and error and experience to arrive at the proper conditions. The suggestions given above on cabinet drying will supply the operator with a starting point for the trial-and-error investigations. It should be remembered that the conditions suggested may not in all cases give the best results.

Packaging

Cabbage.--Dehydrated cabbage requires protection from both moisture and air. To meet government specifications, the air in packages must be displaced. Suitable packing-room equipment will include a picking belt for the removal of defects, a jogging stand to increase the net weight of dried cabbage per can, an over-and-under type of weighing scale, and one of the three effective types of installation for air displacement described in an information sheet on packaging and storage (ACE-185).

It is recommended that mechanical single or double seamers of a type that produces approved hermetic seals be installed, rather than equipment for handling the soldered-top type of can. The vacuum chamber and pump method of removing air is recommended for new installations, and it is preferable that the vacuum chamber be equipped with a sealing head; reduction below 2 percent of oxygen would make this type of equipment necessary when and if specifications are issued for compressed cabbage. The reasons for a maximum of 2 percent of oxygen are urgent. The purpose is to save the flavor, color, and vitamin C by the elimination of air. Analysis should not be made until 12

or more hours after the cans have been filled and sealed. A description and diagram of methods and equipment for gas analyses of cans will be sent on request.

In commercial practice, purging out air by the use of a cylinder of carbon dioxide without a meter has produced irregular results, ranging from 1.5 to 8 percent of oxygen. Records obtained with an inexpensive iron-case gas meter have shown that 1 cubic foot of carbon dioxide will reduce the oxygen content in the filled can down to 1.8 to 2.4 percent in 10 seconds and 1.2 to 1.6 percent in 30 seconds; 2 cubic feet will reduce it to 0.8 to 1.0 percent in 60 seconds.

Five-gallon square cans can be seamed at the rate of 16 per minute. Still other equipment evacuates cans, adds carbon dioxide or nitrogen, and seals them in the chamber at the rate of 1 can per minute.

Dried cabbage as now packed weighs 5 to 7½ pounds per 5-gallon can. When it is warm, dried cabbage is more pliable than when cold; hence packing when warm preserves the size of flake better by lessening breakage.

Celery.--Dehydrated celery is commonly ground to produce celery salt, and is also used as flakes in some soup mixes. Dehydrated leaves, stalks, and roots are three commercial forms of dried celery. Celery may be ground to a powder in a hammer mill, and if ground, a shaker screen will be needed. Because celery is comparatively low in sugar content, the powder is not nearly so hygroscopic as are onion and garlic powders. For this reason, celery salt is not likely to cake during grinding or use. Like other seasonings, dehydrated celery is packed in cans or cartons that protect it against moisture absorption and loss of aroma. It is not necessary to protect it from contact with air. For wholesale purposes in domestic trade, cartons lined with two sheets of waxed paper are suggested. Ground celery is packed at the rate of 20 to 25 pounds to a 5-gallon unit.

Storage of Packaged Product

When air temperatures are over 85° F., only a part of the cooling will take place while the material is exposed on the picking belt. Completion of the cooling to 90° will take place satisfactorily after the material is packaged if the packages are kept separate from others. The rate of cooling will be very much slower if the cartons are stacked in a compact pile; the cooling that will occur in an isolated carton in 7 hours will require 7 days in a compact double stack, and 7 weeks in a compact stack 4 cartons thick. On the other hand, close stacking of cooled cartons in large blocks lessens the rate at which heat will be absorbed. This fact can be used to advantage when the product is in transit through warm regions. The temperature of packaged material can be taken by placing a thermometer in the center of the carton and reading after 10 minutes.

Inspection and Specifications

Purchases of dehydrated vegetables for the several government agencies are inspected by the Fruit and Vegetable Branch of the Food Distribution Administration. Processing procedures are noted and the finished product is

inspected for quality according to the specifications under which the purchase is made. Certificates are issued only when inspections are made on the sealed containers representing the shipment.

In order to facilitate inspection and as a direct aid to the manufacturer certain steps should be followed. The packaged material should be coded and warehoused by coded lots. The coding can follow any system desired but should impart the following information: Product, type, year, month, day, and shift.

Samples are drawn at the rate of approximately 1 container per 100 and representative samples are taken. The containers are checked for condition and the net weight determined by subtracting the tare weight from the gross. The entire contents are removed from the can and mixed thoroughly. A cross-section is taken to make a composite sample and filled and sealed into previously dried jars. Examinations for defects, uniformity of size, presence of fines, and color of dry product can be made on the remainder and most of the material returned to the packer for repackaging.

Laboratory analyses are made to determine the moisture content, enzyme inactivation, reconstitution, and other factors as outlined in the specifications under which the product is being graded. Upon completion of the inspection the results are forwarded to the contractor and purchasing agency. Official certificates are issued and dated according to the date of the last day required to complete the analysis. These certificates serve as a basis for payment when the merchandise is received and accepted.

Purchases are made on Quartermaster Corps Tentative Specifications which are obtainable through the Chicago Quartermaster Corps, 1819 West Pershing Road, Chicago, Illinois, or Tentative FSC Specifications obtainable through the Fruit and Vegetable Branch of the Food Distribution Administration, U. S. Department of Agriculture.

Reconstitution and Quality of Cabbage

The purpose of reconstitution is to restore enough moisture to the material to produce optimum quality. Long holding at boiling temperature is highly detrimental to the color, taste, flavor, and nutritive value of the vegetable. Therefore it is best to subject cabbage to a moderately long soaking followed by a relatively short boiling or cooking period. When the material is to be used as salad or cole slaw, obviously cooking is undesirable and slightly longer soaking may be required.

Cabbage is one of the best sources of ascorbic acid in the diet. While there is loss in the dehydration process, more than 20 tests at the Western Regional Research Laboratory have shown that the freshly dehydrated material still contains 300 to 400 milligrams per 100 grams of dry cabbage.

In reconstituting samples for testing, add 1 part by weight of dried shredded cabbage to a consistent weight of water (10 to 15 parts). Soak for 1 hour; then simmer for 10 to 20 minutes in the same water. Drain through an 8-mesh

strainer for 2 minutes and weigh. The reconstituted weight will be approximately 8 to 12 times the original weight of vegetable. Longer soaking will give a plumper product and slightly greater drained weight. Longer boiling may cause deterioration in flavor and color.

In preparing directions for home and institution use of this dehydrated product, the producer should determine the amount of water and the soaking and boiling time necessary to give a moist cooked product, without excess water. A large part of the ascorbic acid will be lost if water is discarded.

Reconstitution of Celery Stalks

Dehydrated celery stalks and leaves are used almost entirely as seasoning agents. Reconstitution tests are not feasible for the leaf powder but may be desirable for the stalks. Plant operators who wish to make tests should regard pungency as a highly valuable characteristic, and texture as secondary in importance. Minimum amounts of water should be used, the material should be soaked rather than boiled and the quality and use of excess water should be considered. Producers who make recommendations for home and institution use of the dried celery stalks should recommend also the use of this excess water in cooking. The rehydration test as outlined for cabbage may be applied to celery.

For further detailed information address inquiries to the Western Regional Research Laboratory, Albany, California, or to the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Washington, D. C.

(Certain portions of the material presented above were supplied by the Bureau of Plant Industry, Soils, and Agricultural Engineering, and Oregon State College.)

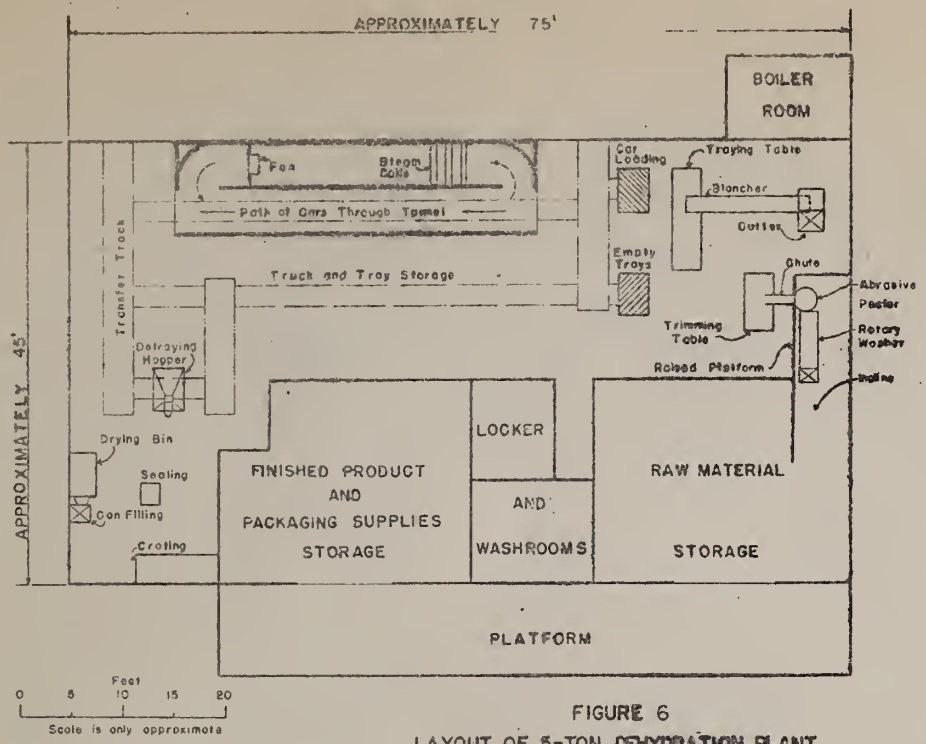


FIGURE 6

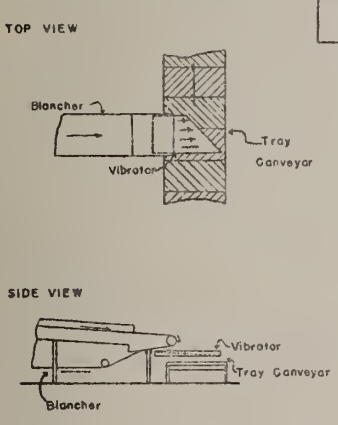
LAYOUT OF 5-TON DEHYDRATION PLANT

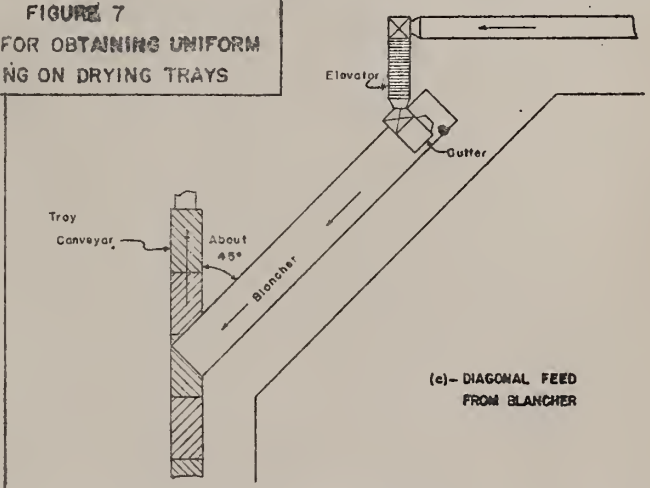
(POTATOES, CARROTS, AND RUTABAGAS)

FIGURE 7

METHODS FOR OBTAINING UNIFORM SPREADING ON DRYING TRAYS

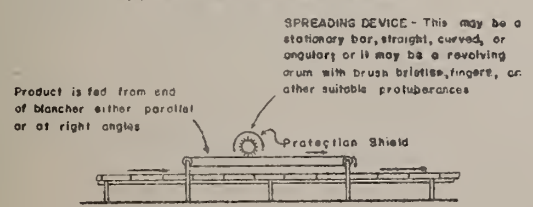
(a)— VIBRATOR OR SHAKER



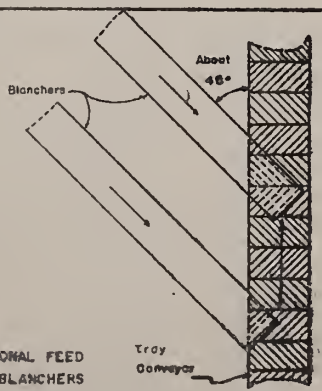


(c)— DIAGONAL FEED FROM BLANCHER

(b) — SYNCHRONIZED SPREADING BELT



The movement of the trays is synchronized with the movement of the spreading belt.



(d)— DIAGONAL FEED FROM TWO BLANCHERS